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Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

PRELIMINARY REPORT ON THE TECHNOLOGICAL RESEARCH OF THE TRIAL MINING AT KIPP MINE, ALBERTA

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ABBREVIATIONS USED IN THE REPORT

TMP - Trial Mining Program

WL - west level

EL - east level

m - metre

PSRL - Precambrian Shield Resources Ltd.

AMCL - Associated Mining Consultants Ltd.

1 S - No. 1 south

2 S - No. 2 south

CMRC - Coal Mining Research Centre

INTRODUCTION

HISTORICAL BACKGROUND

The first coal mine in Alberta was opened on the banks of Oldman river near Lethbridge by Nicholas Sheran in 1872. Coal from this mine was hauled to Benton, Montana by ox-train for several years. During the construction of Canadian Pacific railway in the vicinity of the rocky mountains, coal used to be hauled from the U.S. But in 1881 with the opening of a coal seam in the Lethbridge district, coal started moving from Lethbridge to Medicine Hat for use in locomotives. The coal was found so satisfactory that a narrow gauge railway was built to Lethbridge and a mine opened in that area.

Later, numerous small to medium sized underground mines were in operation. The most recent mine was closed down in 1964. The larger mines were operated by the Lethbridge Collieries Ltd. and the Canadian Pacific Railway for the light industrial, domestic and railroad markets. Production has been exclusively from the "Galt Seam", which appears to be a persistent unit in most of the area. During the above period some practical experience with strata conditions was gained. Besides, during the 1950's and 1960's several strata control studies were undertaken by CANMET.

From 1972 to 1978 several exploration drillings were undertaken in order to obtain information on lithology and structure of the rockmass as well as to firm up the estimates of coal reserves, seam composition and strata conditions. In 1978-82 Pacific Petroleum Ltd. (later Petro-Canada) undertook some geotechnical reviews, sank a shaft and made some studies for a large scale underground mine in the Lethbridge property, known as the Kipp Mine. The shaft is 4.5 m in diameter and concrete lined to a depth of 235 m. Underground drivage from the shaft bottom in the Galt Seam has extended for about 200 m. In July of this year Precambrian Shield Resources Ltd. (PSRL) and Petro-Canada entered into an agreement whereby PSRL assumed the role of managing operator of the Kipp Mine for the purpose of conducting a Trial Mining Program (TMP).

Fording Coal Ltd. is also actively looking and appears optimistic about opening a large underground mine on the Shaughnessy property in this coalfield.

LOCATION AND MAPS

The Kipp Mine is located 16 km (approx.) northwest of Lethbridge. The Picture Butte property lies adjacent to it on the northeast. For locations refer to the following figures:

Fig. 1 - Location map

Fig. 2 - Lease map of Kipp, Picture Butte, Lethbridge and Shaughnessy properties (4)

OBJECTIVE OF THE PRESENT WORK

Precambrian Shield Resources Ltd. and Petro-Canada jointly own Kipp and the Picture Butte properties. In the early part of 1982, PSRL decided to try a certain type of test mining at Kipp Mine which would be followed by some exploratory drilling work at Picture Butte. The objective was to identify potential mining problems to evaluate the results of driving headings in various directions and evaluate various roof support methods, which might be incorporated into future mine design and mining practices at the underground mines at Picture Butte and at Kipp. Accordingly, the work of test mining was initiated at Kipp Mine on July 26, 1982. Associated Mining Consultants and Golder Associates together with CMRC were engaged to perform the geological, geotechnical and analytical work. In this connection PSRL approached the Coal Research Laboratories (CRL)/CANMET in Calgary for participation and cost sharing. The merit of the proposal was studied in detail by CANMET and accepted with the following objectives in mind:

(a) Ground control evaluation:
Testing of different support systems; relating mining conditions to drill hole data at one site and correlating this with drill hole data at other sites for the same seam.

(b) Longwall mining in the plains:
To determine the technical feasibility of longwalll mining in the plains. This parallels CANMET's efforts to try longwall mining in the mountain regions of western Canada.

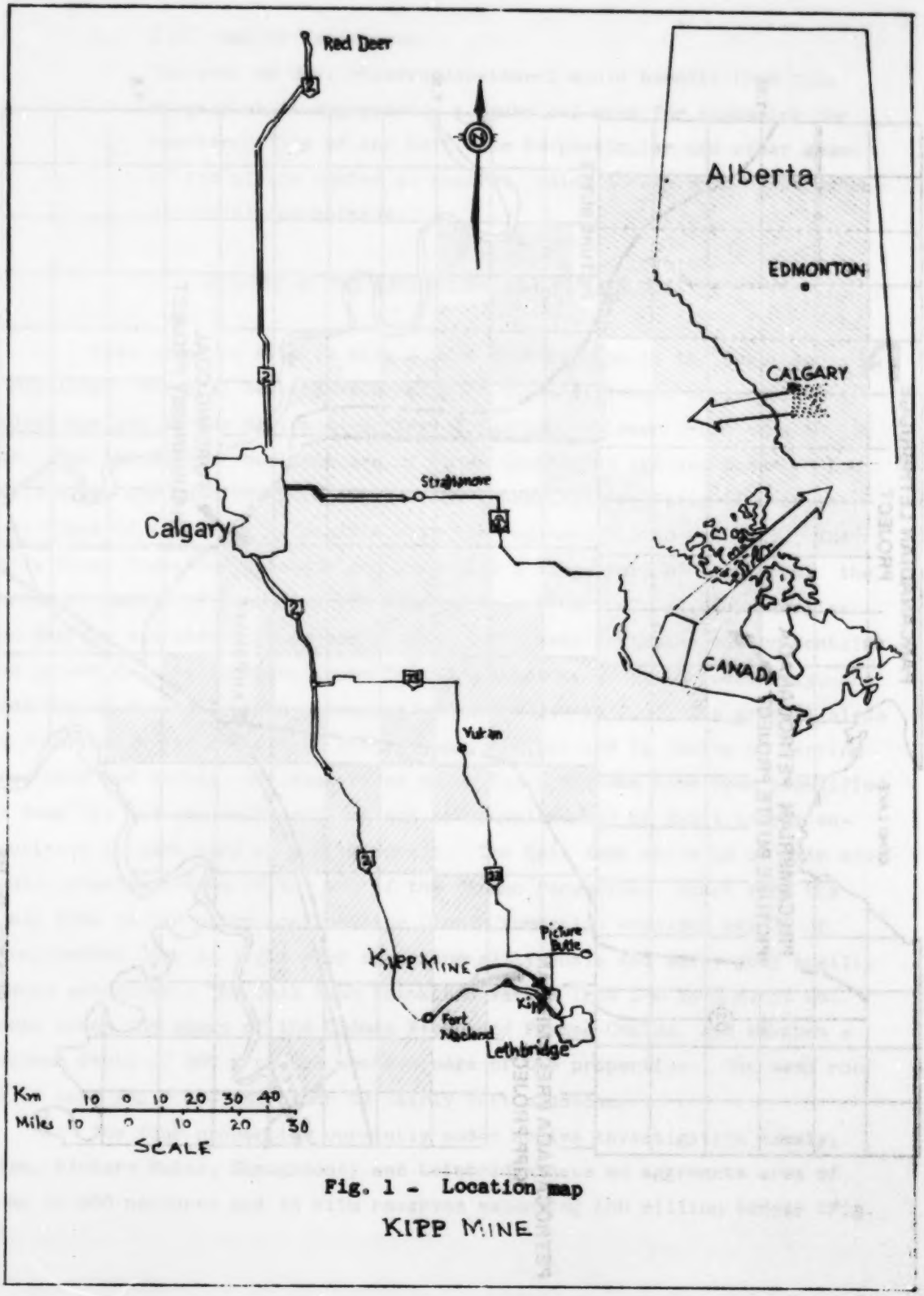


Fig. 1 - Location map

KIPP MINE

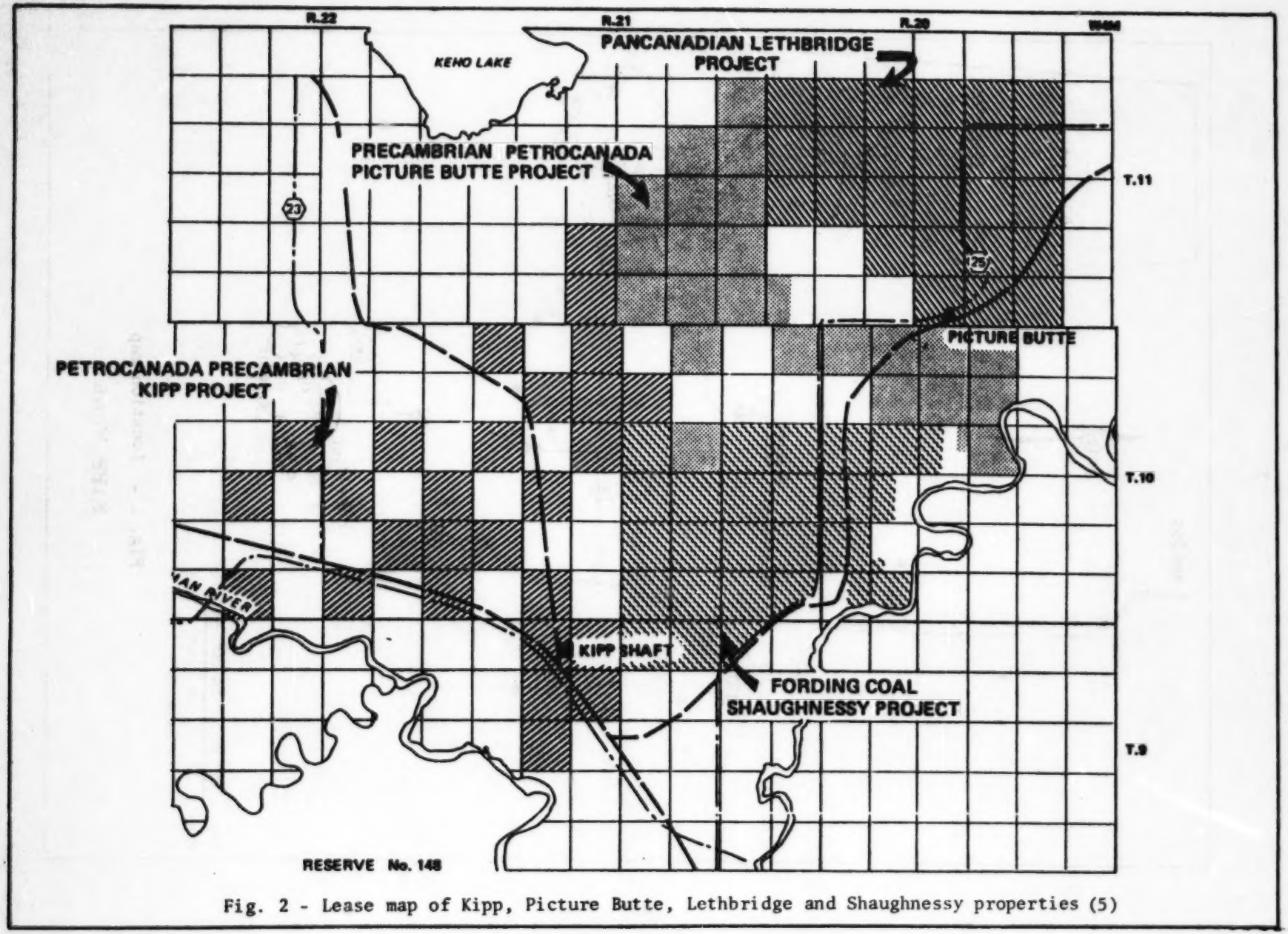


Fig. 2 - Lease map of Kipp, Picture Butte, Lethbridge and Shaughnessy properties (5)

(c) Coal reserve assessment:

The work on coal reserve assessment would benefit from this program as it may provide a technical base for assessing the recoverability of the Galt Seam in particular and other seams of the plains region in general, using modern mechanized underground mining methods.

GEOLOGY OF THE LETHBRIDGE COALFIELD AREA

Coal seams in Alberta have a wide distribution in the Cretaceous formations. The coal bearing beds occur in three different horizons. The oldest horizon in the Blairmore-Kootney formation is Lower Cretaceous in age. The two younger horizons are of Upper Cretaceous age and occur in the Belly River and Edmonton Formations. The Lethbridge Coalfield lies on the east flank of the Alberta Syncline with the regional dip to the west. The Belly River Formation outcrops and underlies a large part of this area. the surfacial mantle of glacial drift ranging from 45 m to 75 m thick overlies the Bearpaw and Oldman Formation rocks. The Oldman Formation member contains the principle coal horizons found in the Lethbridge area. Structurally, the beds dip to the west at an overall gradient of 1.0 to 2.0. The gradual slope is interrupted by small local folds or undulations and by faults of varying frequency and throw. At least three major fault systems have been identified by deep oil and gas well drilling and are supplemented by fault traces encountered in past deep mine development. The Galt Seam which is of main economic interest occurs in the top of the Oldman Formation. Apart from the Coaly zone in the upper portion, the Oldman formation consists mainly of inter-bedded dark to light grey shale and silty shale and soft, grey argillaceous sandstone. The Galt Seam thickness varies from 1 m to 3 m; it outcrops along the banks of the Oldman River and Pyamee Coulee, and reaches a maximum depth of 300 m on the western edge of the properties. The seam roof is of weak shale and the floor is fairly soft mudstone.

The four properties currently under active investigation namely, Kipp, Picture Butte, Shaughnessy and Lethbridge have an aggregate area of some 42 000 hectares and in situ reserves exceeding 600 million tonnes (Fig. 2).

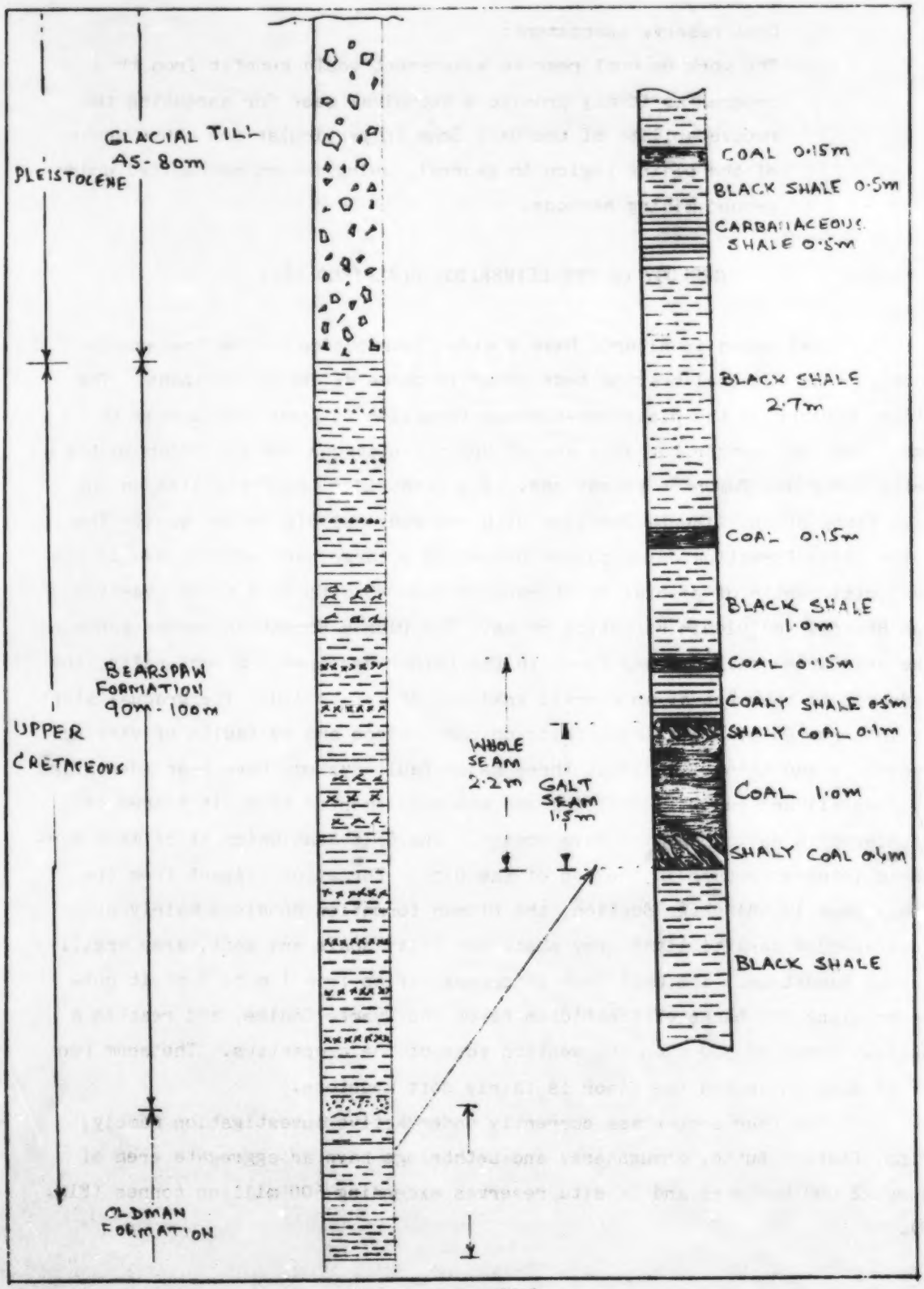


Fig 2 - Stratigraphic column and coal section Kipp Mine (1)

DESCRIPTION OF TRIAL MINING PROGRAM

GENERAL GEOTECHNICAL CHARACTERISTICS

Coal in this area is generally hard and more competent than the rocks in the roof and floor. The coal has two cleats, one in a direction N50°E and the other in a direction N40°W almost at right angles to the former. The main cleat (N50°E) is always under 0.3 m in spacing. As the top glacial till consists of loose sand, gravel and clay and because the rocks in the Bearpaw and Oldman Formations consist of weak rocks, subsidence can be a serious problem. Associated rocks are in general, soft with a low degree of maturity. Mudstone is a common rock type. Up to about 80 m of soil and glacial debris overlie the bedrock. In the development stage any water problem will depend on the permeability of the superincumbent strata and the ground water regime but in final extraction water may become a problem due to subsurface movement of strata.

GEOTECHNICAL STUDY

The most favourable method of extraction may be considered as the mechanized longwall and it calls for a thorough geotechnical study for its successful implementation. The study items can be stated as follows:

(a) Floor conditions:
- strength properties
- heaving characteristics
- effect of water

(b) Roof control:
- stability and best alignment of roadways and longwall face
- suitability of support systems
- caving characteristics of superincumbent strata
- most suitable horizon of mining and width of roadways

(c) Ground water regime.

(d) Any other potential problems in mining the Galt Seam.

INITIATION OF THE PROJECT

Only an underground method of mining is practical for the area under study. Therefore, PSRL was interested in carrying out a feasibility and mine design study for this project for this purpose. The Galt Seam exists in both Kipp and Picture Butte. In 1981, Golder Associates conducted some geotechnical studies and identified certain specific problems. But to have a firm base for any feasibility study for Picture Butte it was decided to conduct a Trial Mining Program (TMP) at Kipp where a mine shaft and underground equipment were available. It would then be followed by a drilling program in 1982/83 at Picture Butte. Based on this PSRL signed an agreement with Petro-Canada and commenced the TMP which lasted 3 months.

THE STUDY PROGRAM

It was decided to carry out roadway drivage for 3 months with a continuous miner to complete 600 m of drivage producing about 10 000 tonnes of coal. Figure 4 shows the original layout of roadways which, however, was altered as in Fig. 5 to confirm with underground conditions and to meet a time contraint. It was planned at the same time that different kinds of roof supports would be tried during the test period. Details of these supports are shown in Fig. 6 and Fig. 7. The plan also included regular monitoring of the various test sections for strata behaviour.

In view of the above, a contract was given to Associated Mining Consultants Ltd. together with Golder Associates to carry out strata control/ geotechnical tests which included:

(a) Comparison of mining conditions between Kipp and Picture Butte by evaluation of the existing geotechnical and stratigraphic data.

(b) Field investigation of the existing workings at Kipp driven prior to December 1981.

(c) Correlation of data from previous studies as well as from the present investigations.

(d) Control and co-ordination of instrumentation and of in situ testing.

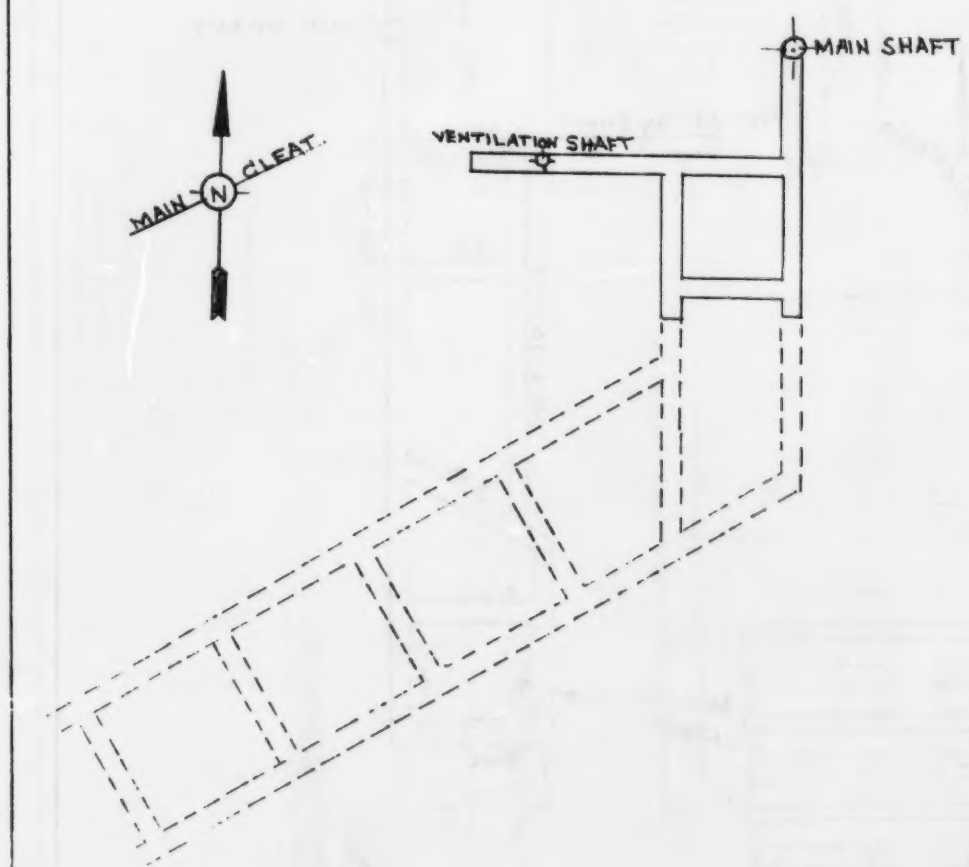


Fig. 4 - Proposed development plan Kipp Mine (4)

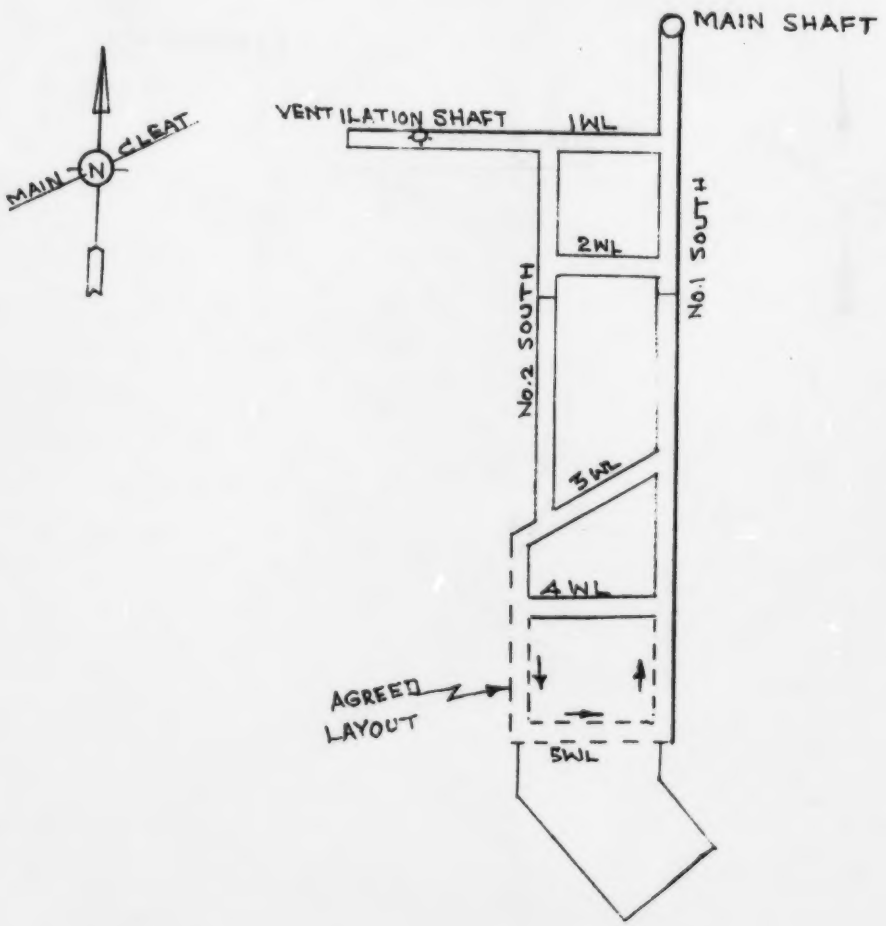


Fig. 5 - Revised layout Kipp Mine (4)

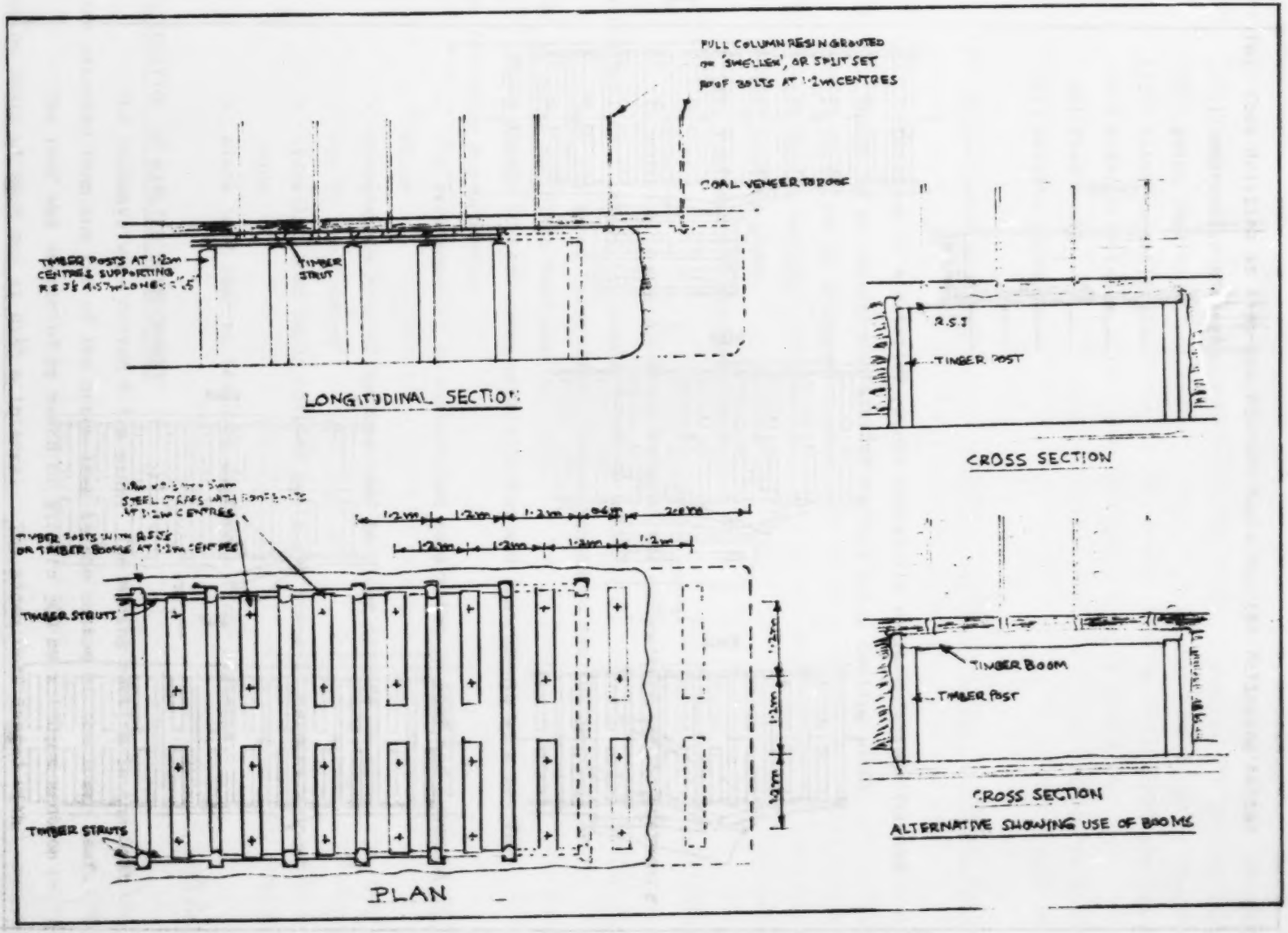


Fig. 6 - Support of roadways Kipp Mine (4)

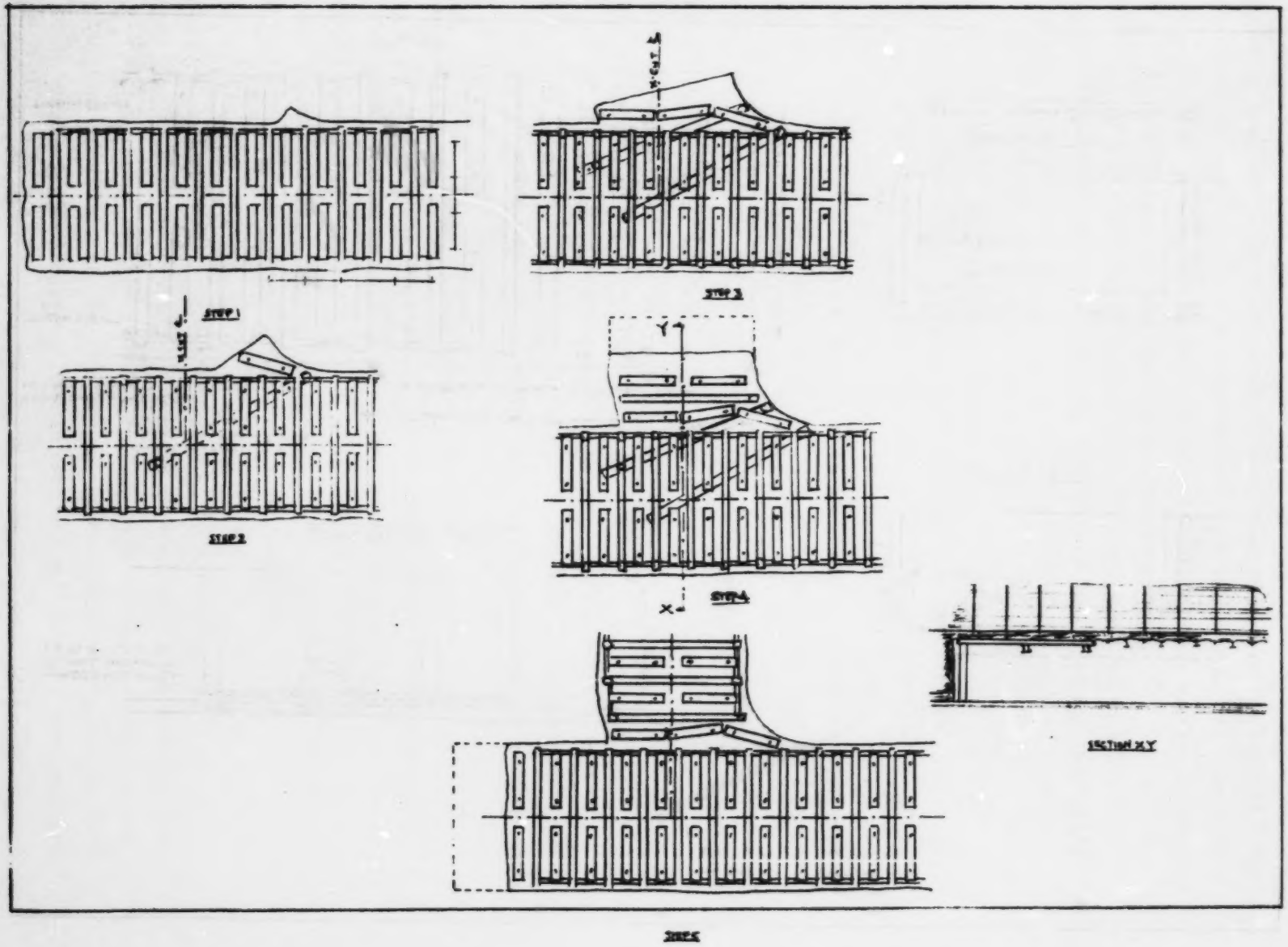


Fig. 7 - Support of intersections Kipp Mine (4)

(e) Core drilling at Kipp and Picture Butte for the following tests:

(i) compressive strength

(ii) point load

(iii) slake durability

(iv) plasticity index

(v) free swell

(vi) calcite content

(f) Ground water studies.

(g) Preparation of a detailed report containing recommendations for the design of an underground mine at Picture Butte dealing with:

(i) direction of drivage

(ii) mining horizon

(iii) roadway width

(iv) roof support systems.

In addition to the above the task of the contractors was to advise on the applicability of the longwall mining method.

Over and above these works, PSRL intended to use the services of CMRC to carry out plate load bearing tests.

A number of test sites were selected and instruments were set for the following measurements:

- rod extensometers to measure bed separation in roof and heave in floor
- convergence rods to measure roof to floor closure
- rib to rib closure
- hydraulic load cells between posts and beams to measure support loads
- plate load bearing tests on different floor horizons.

OBSERVATION OF EARLIER DEVELOPMENT

The roadways were driven 5.5 m wide. The mining section in the Galt Seam extended from the top of the upper leaf to the bottom of the lower leaf.

The roof was supported by means of girders 300 mm x 150 mm section set on posts at each end at 0.45 m interval. The sides were lagged with

planks. Many of the girders in No. 1 south were found bent or twisted. The east side of the gallery in No. 1 south was much weaker than the west side, whereas in No. 1 west and in No. 2 west galleries, both sides were competent. There was floor heave at one place in No. 1 west level.

In No. 2 west level a cluster of roof bolts and truss bolts were found set on the roof. The roof sagged throughout the area as, indicating bed separation.

MINING METHOD AT THE TRIAL MINING PROJECT

The thin mudstone above the lower leaf was used as the roof of the roadways at most locations. In order to obtain a mining section of 2.1 m, a part of the floor mudstone was ripped. The width of the galleries were mainly kept at 4.88 m. Figure 8 shows the length, direction and position of the individual drivage sections during TMP. It also shows the type of supports used.

OBSERVATIONS AND MEASUREMENTS

Roadway (Fig. 8)

1 S between 2 & 3 WLs (completed on August 6/82)

The east side continued to be weaker. Roof support seemed to be adequate. The resin bolts with metal straps appeared to support the roof well. Roof extensometer as installed at 3 WL, did not show any roof movement.

3 WL up to 2 S (completed on August 11/82)

This roadway was parallel to the direction of cleat. The roof and sides were found to be in good condition. Load cells at this location recorded even pressures of 320 psi on each side of the roadway. The extensometers did not show any roof movement. The convergence recorder installed between the roof and floor did not record any movement.

2 S from 2 WL to 3 WL (completed on August 20/82)

The previous development work as carried out by Petro-Canada, was done with the roof horizon at 0.2 m to 0.25 m above the upper leaf of coal. PSRL stabilized the 2 WL junction and the heading with additional support before commencing any drivage. The drivage was continued at the same roof horizon for 5 m and then lowered to the top of the upper leaf. Another 9.5 m

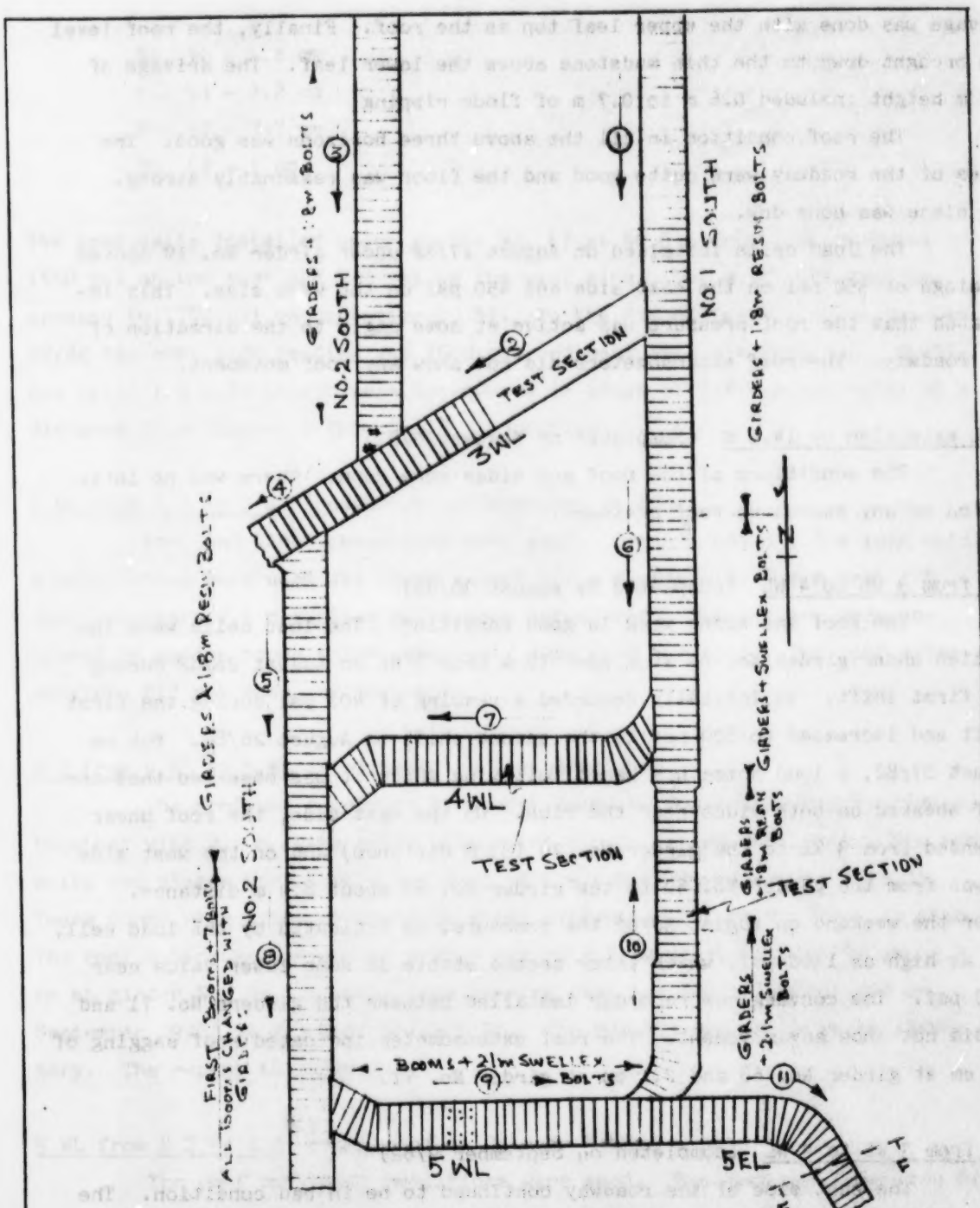


Fig. 8 - Trial mining program (underground drivage)

drivage was done with the upper leaf top as the roof. Finally, the roof level was brought down to the thin mudstone above the lower leaf. The drivage of 2.1 m height included 0.6 m to 0.7 m of floor ripping.

The roof condition in all the above three horizons was good. The sides of the roadway were quite good and the floor was reasonably strong. The place was bone dry.

The load cells installed on August 17/82 under girder No. 19 showed readings of 350 psi on the east side and 450 psi on the west side. This indicated that the roof pressure was active at some angle to the direction of the roadway. The roof extensometers did not show any roof movement.

3 WL extension by 14.5 m (completed by August 25/82)

The conditions of the roof and sides were good. There was no indication of any excessive roof pressure.

2 S from 3 WL to 4 WL (completed by August 30/82)

The roof and sides were in good condition. The load cells were installed under girder No. 60 at a spot 12 m from 3 WL on August 26/82 during the first shift. It initially recorded a reading of 400 psi during the first shift and increased to 800 psi in the second shift on August 26/82. But on August 27/82, a loud noise was heard following which it was observed that the roof sheared on both sides near the ribs. On the east side, the roof shear extended from 3 WL to the girder No. 78 (33 m distance) and on the west side it was from the girder No. 60 to the girder No. 67 about 8.4 m distance. After the weekend on August 30/82 the pressure, as indicated by the load cell, was as high as 1300 psi, which later became stable at some lower value near 1100 psi. The convergence recorder installed between the girders No. 71 and 72 did not show any movement. The roof extensometer indicated roof sagging of 1.9 cm at girder No. 68 and 2.1 cm at girder No. 77.

1 S from 3 WL to 4 WL (completed on September 9/82)

The east side of the roadway continued to be in bad condition. The roof extensometer installed near the girders No. 40, 53, 58 and 63 showed roof sagging as follows:

No. 40 - 1.2 cm
No. 53 - 2.2 cm
No. 58 - 3.7 cm
No. 63 - 1 cm.

The load cells installed under girder No. 67 at 40.8 m from 3 WL recorded 1550 psi on the east and 750 psi on the west side. The east side load increased to 1700 psi on September 10/82. On the day of inspection on October 22/82 the east side reading was 2000 psi and west side was 1000 psi. Swellbox bolts 1.8 m in length were introduced in place of 1.8 m resin bolts at a distance 23 m (approx.) from the 3 WL junction.

4 WL from 1 S to 2 S (completed on September 16/82)

Roof and floor conditions were good. Swellex bolts 1.8 m long with a metal strap were used all along except for a distance of 4.2 m from 2 S junction where 2.1 m swellex bolts were introduced. The girders were replaced by wooden booms which adequately supported the roof. The roof extensometers did not show any movement.

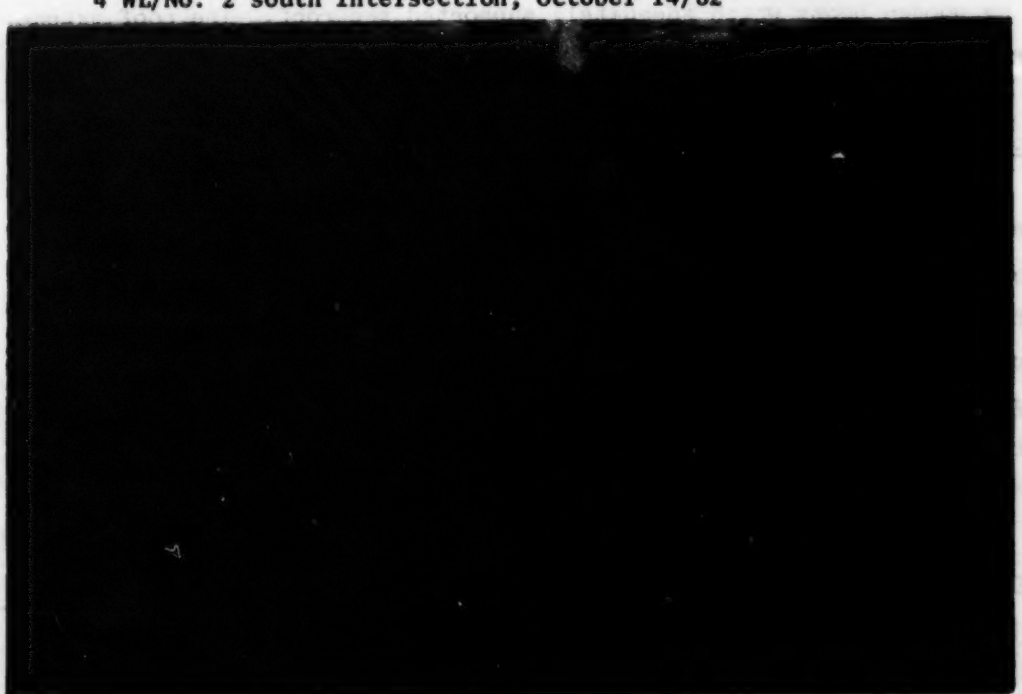
2 S from 4 WL to 5 WL (completed on September 27/82)

The roof was supported by wooden booms on posts at 1.2 m intervals, together with 2.1 m resin bolts with metal straps in between booms. The roof bolts and plates worked well but most of the wooden booms broke (Fig. 9). These booms were later replaced by steel girders of 150 mm x 125 mm in size. The roof extensometers showed a roof sag of 2.2 cm at girder No. 87 and 3.3 cm at girder No. 94. A plate load bearing test was conducted by CMRC on September 29/82 at 2 S face below 5 WL. The results seemed to be satisfactory. The report is awaited.

5 WL from 2 S to 1 S (completed on October 4/82)

The roof and floor conditions were good. The roof was supported by wooden booms (4.5 m) on posts in addition to the 2.1 m swellex bolts and metal straps. Between girders No. 12 and 15 the metal straps were replaced by wire mesh which appeared to be satisfactory.

Looking south along No. 2 south roadway from just inbye 4 WL/No. 2 south intersection, October 14/82



Looking north along No. 2 south roadway from just outbye No. 2 south/5 WL intersection, October 14/82

Fig. 9 - Broken wooden booms in No. 2 south Kipp Mine (5)

1 S from 5 WL to 4 WL (completed on October 8/82)

The first 20 m of the roadway was driven 4.88 m wide and the remainder 4.2 m wide. In the 4.88 m wide section of the gallery 4.5 m x 150 mm x 200 mm girders were placed on posts, whereas in 4.2 m wide section 4.12 m x 125 mm x 150 mm girders were used. Swellex bolts 1.8 m long were used up to a distance of 23 m from the 5 WL and 1.8 m resin bolts for the section up to 4 WL. Later the girders were removed from locations 109 to 125. The convergence recorders and the roof extensometers were installed. During the inspection on October 22/82 the roof was found sagging with a crack running parallel to the roadway. It was interpreted as a sign the crack would be opening further.

5 EL to fault (completed on October 15/82 first shift)

This roadway was driven for 10 m in an eastern direction and then turned southeast. A fault was encountered about 19 m from the centre of the 1 S roadway. On the basis of this single intersection, the fault appears to be striking east-west. However, it is risky to judge the direction based on one point extrapolation. The inclination of the fault plane is about 60°. It is likely that the fault trends essentially north-south east of the present development. The roof condition was much worse on the east side than the west side of the gallery where the fault was encountered. There was some indication of roof weight from the face up to the junction of 1 S.

A drivage was advanced by 4.5 m into the stone. Two holes each 5.2 m long were drilled; one into the roof and one into the floor. The coal seam could not be located on the other side of the fault.

Core drilling in the roof and floor was done at two places in 2 S; one between 2 WL and 3 WL, the other below 5 WL. Hole depth was about 20 m in the roof and 10 m in the floor. Core recovery was good. The core samples are being tested by Golder Associates and the results will be available soon.

ANALYSIS OF THE RESULTS

DIRECTION OF ROADWAY

The roof load was found to be excessive and uneven when any roadway was driven along the south or the north direction, where the following were observed:

(a) The booms plus the roof bolts with straps were inadequate for support.

(b) The roof bolts with straps cannot prevent bed separation, whether used with resin or swellex bolts.

(c) Support by girders (4.5 m x 150 mm x 200 mm) should be considered a 'must'.

The reason for excessive and uneven roof load may be due to a fault running close and nearly parallel to a north-south direction and it calls for systematic analysis of the test data.

The condition of the roof and sides were much better in the roadways driven in SW, SE, E, W and NE directions. The roof load was not excessive and was found to be even across the roadway. Wooden booms plus the roof bolts with straps were adequate for supporting the roof. At many places, even 2.1 m resin bolts with straps were able to hold the roof satisfactorily.

HORIZON OF DEVELOPMENT

(a) Roadway No. 2 south between 2 WL and 3 WL

(i) Roof horizon was maintained at 0.2 m to 0.25 m above the upper leaf and the roadway was advanced for 5 m. The condition of the roof here was good and could be adequately supported by girders on posts together with resin bolts with straps.

(ii) Further 9.5 m drivage was done with top of the upper leaf as the roof. Here the conditions of the roof remained satisfactory and could be supported as described in (i) above.

(iii) Finally the roof horizon was lowered to the mudstone above the lower leaf. The roof continued to be satisfactory.

(b) Roadway No. 2 south from 4 WL to the face below 5 WL and 20 m (approx.) in the 5 WL from 2 south, the roof horizon was maintained at 0.2 m above the upper leaf.

(i) Wooden booms were tried in place of girders. The booms started breaking in No. 2 south, from the point where the roof horizon was altered.

(ii) The roof condition was bad throughout the drivage in this horizon in No. 2 south.

(iii) In 5 WL, booms were used in place of girders in conjunction with bolts and straps. This roof support was adequate.

(c) 5 EL from 1 south. For some distance the roof horizon was the mudstone above the lower leaf. Later the horizon was taken up to a level leaving 0.2 m of coal in the upper leaf. In this horizon drivage was continued up to the fault. The roadway was partly supported by girders and partly by booms. There was roof load of 675 psi on one side and 1000 psi on the other, but whether the girders of the booms, held the roof well.

TYPE OF SUPPORTS

(a) Resin bolt - 1.8 m or 2.1 m long. The regular brown resin cartridges normally took between 8 to 9 minutes for setting. To reduce this setting time, one black resin cartridge (quick setting type) was put at the back of the hole together with 5 brown cartridges in each hole. This, in effect, reduced the setting time by between 2 to 3 minutes. It is safer to use 2.1 m long bolts.

(b) Swellex bolts - 1.8 m or 2.1 m long and metal straps along with girders or booms. Installation of this type of bolt was quicker and very effective. These bolts supported the roof very satisfactorily. There was not a single instance where it failed under roof pressure. Swellex bolts of 2.1 m long will be more than adequate.

In 3 WL test section girders No. 7 to No. 23 were removed to see the effects. The roof load was then only on the resin bolts and metal straps.

In 4 WL test section the girders No. 10 to 25 were removed and the roof load was thereby on the swellex bolts and metal straps.

In 1 south test section girders No. 109 to No. 125 were also taken out. The roof load supported by girders No. 109 to No. 117 was taken by the Swellex bolts and that on the girders No. 118 to No. 125 by the resin bolts.

Regular monitoring was being continued in the three test sections. The results will indicate whether the roof bolts with straps only would be adequate for roof support.

(c) Booms on posts. This type of support could not hold the roof in 2 S, even in conjunction with roof bolts and straps.

(d) 3-way intersection support. 2 girders 6 m x 200 mm x 150 mm together (factory welded) were used on posts in addition to roof bolts and straps. This was adequate support in each 3 way junction.

(e) Wire mesh with bolts - in 5 WL. This was used for some distance. Its performance in this particular place was satisfactory. There is a good possibility that it can be used for a significant length of the roadways.

FLOOR CONDITION

Strength - CMRC conducted plate load bearing tests at 2 S below 5 WL.

(a) Mudstone - quite competent and strong enough for chocks and shield supports of the type used in longwall mining, if dry. When wet for several hours it became weak and therefore wet conditions may cause problems for the above supports.

(b) Coal - has much higher strength than needed for the above mentioned supports.

Thus in practice if certain locations in the mine are wet, the problem may be overcome by leaving some floor coal.

Proneness to heave - constant monitoring of the roadways is being done by AMCL. Results will be available after December 1982.

FAULT

5 EL heading towards SE met a fault. The coal seam was quite competent near the fault zone. The roof and the sides near the fault were similar to the conditions in the roadway 10-15 m out by the fault.

The above two conditions are an indication that the fault might be of the tension type.

Two holes 5.1 m, one into the roof and one into the floor were drilled to locate the seam. The seam could not be located. The hole in the floor should have been drilled at an angle greater than the angle of the fault. With the information available, it appears that the seam on the other side of the fault might be thrown down. AMCL, is studying the stratigraphy for possible correlation.

The direction of the fault as found in the roadway, appears to be close to east-west but this can only be confirmed by locating the fault at least at two more places. There is a strong possibility of its northerly continuation not far from 1 S. The load cell reading may give some indication in this respect, e.g., the readings of load cells in 1 S increase towards the south and are much higher than the readings in 2 S.

More detailed analysis of the results would be provided in the final report.

CONCLUSIONS

- Mechanized underground mining in the Galt Seam is a definite possibility.
- Excessive roof load in No. 1 south and No. 2 south is possibly due to a fault in the vicinity.
- Development of roadways: no difficulty is foreseen with standard types of roof supports.
- Mining horizon: ideally 0.2 m of coal in the roof and 0.3 m to 0.5 m ripping in floor mudstone would be optimum. In wet conditions, the floor can be kept a few centimetres above the mudstone i.e., some floor coal should be left.
- Roof caving characteristics: appear to be favourable.
- Longwall method of mining appears technically viable for the extraction of the Galt Seam.
- Swellex bolts were quick to install and provided effective support.

RECOMMENDATIONS

(a) The fault encountered in TMP should be thoroughly investigated.
(b) Actual experiments should be done underground to test roof cavability.
(c) Tests should be done for 4-way intersections.
(d) Use of truss bolts should be tried, especially at intersections.

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